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ECOLOGY OF *SCELOPORUS MAGISTER* AT THE NEVADA TEST SITE, NYE COUNTY, NEVADA

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Abstract.— The natural history of *Sceloporus magister* was studied in popu lations at the Nevada Test Site, Mercury. Individuals were marked and kep under surveillance from 1965 through 1970. Reproductive cycles were examine by field observation and by autopsy. Hatchlings appear in the population in Jul and August. Growth is rapid for the first year. Sexual maturity is reached befor the second hibernation or soon after emergence from it. Territoriality is a pro nounced behaviorism; individuals have been observed to remain in a small are for several years. Food consists of arthropods, with ants the predominant item Reproduction occurs during May and/or June with only one clutch per yea Density is variable and depends on the appropriateness of the habitat.

Sceloporus magister are abundant on the rocky foothills, particu larly where large rocks, wood poles or posts, and tree yuccas ar available for basking and hiding. Several other species of the *spino sus* group have been studied. Blair (1960) studied the rusty lizar (*S. olivaceus*) in Texas for five years; Mayhew (1963) reported o the granite spiny lizard (*S. orcutti*) from southern California afte a four-year study. Other reports involving species of the *spinosu* group have been limited both as to time of observation and materia available. Kauffeld (1943) reported a female *S. clarki* from southern Arizona which contained 24 embryonate eggs. Davis and Smit (1953) stated that *S. horridus* in Morelos seemingly laid one clutc of eggs in late July and the first part of August. Davis and Dixo (1961) indicate a longer reproductive period for this species extend ing from May to September.

Sceloporus magister has not been studied intensively. Severa studies include references to egg laying, large eggs contained in female, and age groups. The studies of Axtell (1959), Minto (1959), Smith, Williams, and Moll (1963), Taylor (1936), Steb bins (1954), and Johnson, Bryant, and Miller (1948) refer to aspect of its life history. A recent and more complete study is by Parke and Pianka (1973).

Fitch (1970) adds information to several species and summarize available reproductive data for the genus *Sceloporus*. Stejnege

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(1893) provides no reproductive data, but does discuss habitat, behavior, and feeding habits. His lengthy comments pertain primarily to the systematics of the larger spiny lizards of the Southwest. *Sceloporus orcutti* and *S. boulengeri* are described as new and other related species (*clarkii, spinosus, magister*) are discussed. Richardson (1915) referred only to the habitat and a few behaviorisms.

In 1939 Smith reviewed the genus *Sceloporus*, described several new subspecies and set forth for the first time a phylogeny of the genus. Phelan and Brattstrom (1955) discussed the geographic variations in *S. magister* and described three new subspecies. Tanner (1955) described as new the Upper Colorado Basin population. Larsen and Tanner (1973) are preparing a phylogenetic study of the entire genus using basically external measurements, scale patterns, and skull characters in a computerized analysis. The populations of this species occur in limited pockets, which may account for their not having been studied as intensively as many other desert species have been.

The present study was conducted at the Nevada Test Site under the contract At(11-1)1496 between the U.S. Atomic Energy Commission and Brigham Young University, Provo, Utah.

Study Plots

Four study areas have been used in securing the data. In each area habitat conditions such as wood poles or posts, large rocks, or trees (tree yuccas or cottonwoods) were present. In two areas the populations were marked and studied from 1965 through 1969.

The Knoll study plot was established in 1965 and the first lizards were marked on 3 July. All captures were made by noosing. The plot consisted of a small rocky ridge rising from the bajada, isolated from the other ranges by a small valley on the west and surrounded otherwise by a desert alluvial plain. The lizards inhabit the ledges and rock slides. Although we succeeded in marking 31 lizards and had 26 recaptures, only one hatchling was seen in four years. The area included in this study plot was approximately 2 hectares.

A study plot at Cane Springs was set up in 1966 and the first lizard marked on 28 May. This plot consisted of two areas. One contained the walls of an old rock house and frame room adjacent to it. These are shaded by a large cottonwood tree. Down the slope to the north are poles and posts and the remains of a corral; nearby to the west are rocks and ledges. In this area captures were made by noosing. The other area was south and west of the house. Near the house is a patch of tall grass and brush, which undoubtedly benefits from the shallow water table near the spring. To the west are sparse desert shrubs on a rocky hillside. Three rows of cans were placed through the grass and onto the hill, totaling 39 traps. Each was placed 12.2 m apart, which provided a plat 147 x 37 m. By including a narrow outer margin to the plot and the area of the house, which is adjacent to the plot, there is approximately .5 hectare. The corral area is about half this size. We marked 67 *S.*

magister at Cane Springs and of these 15 were hatchlings. There were 57 recaptures.

Two areas were used to secure lizards for autopsies. One area consisted of large rocks along the road between Cane Springs and the Knoll. The second was along the abandoned road from Mercury Pass into Frenchman Flat. Along this road are power poles, some ledges, and large boulders. All areas range in elevation between 1075 and 1230 m and are in approximately the same type of habitat except as man has modified it.

Home Range and Density

Data for 15 individuals captured and recaptured for 3-10 times show a definite territoriality. In most instances individuals remained within a rather restricted area, except females who seemingly leave their home range to lay eggs. Both sexes may leave if a more favorable area for hibernation is near the area used for summer activity. The general size and shape of some home ranges observed for periods of 2-4 years were similar to those observed for *S. occidentalis*. The areas occupied were surprisingly small for such a large lizard (Fig. 1). Once a territory was established we observed little shifting or enlarging. An adult female #1K was marked in 1965 and caught once in 1966 and 1967. During these three years she was observed within 4 m of each capture. A juvenile #5K captured 6 times in 1966 and 1967 was within an area having a diameter of not more than 15 m. Two juveniles (#3K and #8K), marked on 29 May and 8 June 1966, moved north along the ridge for approximately 310 and 620 m. Both were recaptured in subsequent years and both remained in a small territory (Fig. 1).

At Cane Springs most of the lizards for which we have adequate data were those living along the rock walls or the rows of posts. Thus their territory consisted of a narrow strip which could not be adequately represented by a polygon. An example is an adult male (#18) marked on 9 July 1966 and last seen on 7 May 1970. During five years he was recaptured nine times and observed at a basking site on numerous occasions. Although our visits to this plot were at intervals of several days and not for long periods of time, only on two occasions did we observe him away from the line of posts, once on a rock pile 20 m west and the last time about 200 m west on a ledge.

Each of these territories possessed at least one area for basking or observing, and, in most, several objects were used. Basking sites were usually near a hiding place. For example, #18 used three posts for basking and observation. He was usually high on the post if not on its top. Our approach would send him scurrying from the post and into one of several large bushes at or near the base of the post. Posts, poles, trees, or rocks were not regularly used if some protection (bushes, rock piles, etc.) were not nearby.

Density is difficult to determine because of the variations in habitat. Although the total area at Cane Springs is smaller than at

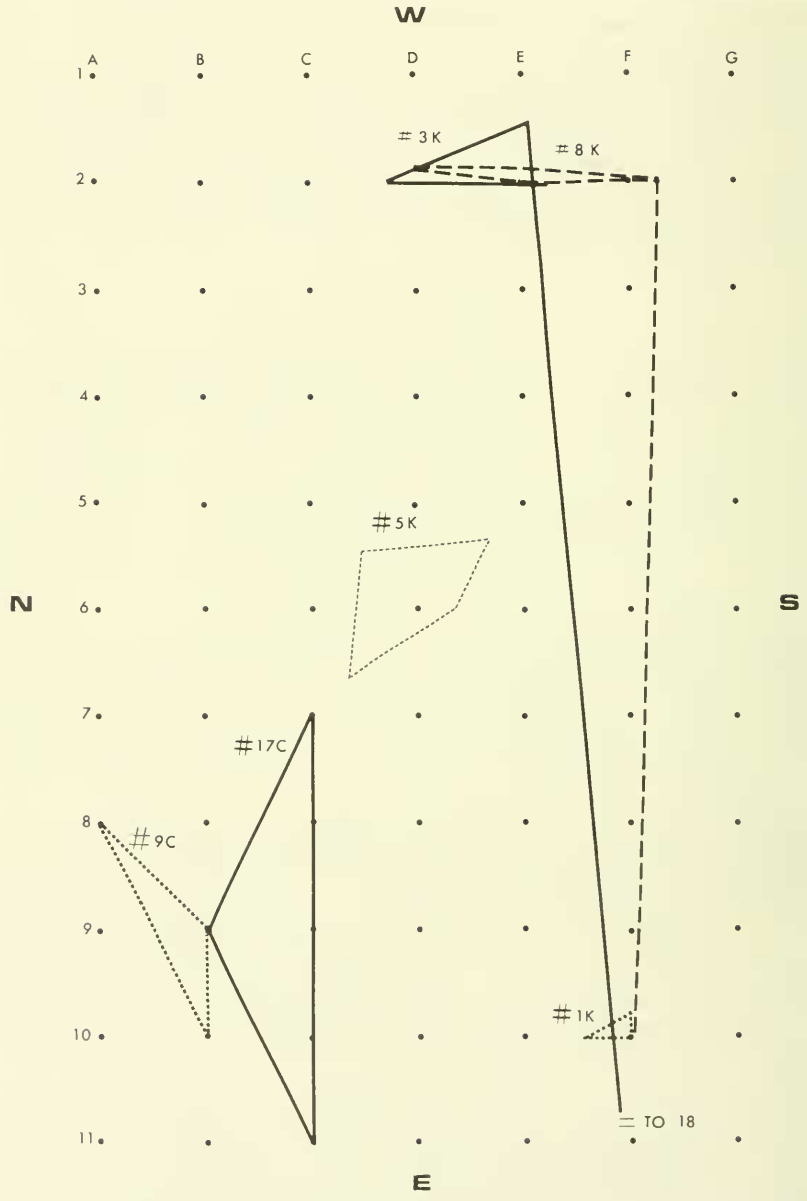

Fig. 1. Home ranges for *Sceloporus magister*. The prefix K = Knoll study plot and C = Cane Springs study plot.

the Knoll, we marked and recaptured 36 more lizards. In 1966 eight lizards were marked at the corral (about 32 per hectare) and 25 at the house and from the can traps (about 50 per hectare). In 1968 seven were at the corral and only 18 at the house and traps. In 1969 twenty were seen at the house and on the plot. During 1966 and 1967 only 12 and 13 individuals were known to be at the Knoll plot (about 6 or 7 per hectare).

Of the three areas for which density data are available, the house and plot area supports the greater density. We recognize in this area more shelter, adequate areas to climb and hide, and because of the abundant vegetation more food. In this species the quality of the habitat is seemingly very important in determining density. Because habitat plays such an important part in the establishment of territories, population densities will vary from a few lizards to as many as 50 per hectare.

Behavior

Desert scaly lizards are active from April to October. Both adults and juveniles were seen 11 April 1970 and adults and hatchlings in mid-September. This species is a persistent basker and may be seen perched on a rock, pole, or some elevated object soon after sunup and until late in the afternoon. During the heat of the day shade is sought. The basking habits are similar to those observed for *S. occidentalis longipes* (Tanner and Hopkin, 1972). Their climbing abilities are remarkable, particularly in trees, where they are very adept at keeping the tree between you and them. In southeastern Utah, this species is so proficient in climbing that collecting is difficult without a gun. In this regard we have found *magister* to be similar to *clarki* and presumably *olivaceus* (Blair, 1960).

Sceloporus magister is a large, heavy-set lizard which usually produces a rustling sound as it scurries for cover. Because of its brisk scampering, ranchers in southern Utah call it the bull lizard. Although it is not as speedy as some lizards, in its habitat of trees, boulders, and poles it is well equipped to escape a pursuer.

Individuals have been recorded to remain on an object for several hours, basking at times and/or loafing in the shade. Often they cling head down as if watching for prey or an approaching enemy.

For active individuals we have cloacal temperatures ranging from 29 to 35 C and averaging 32.8 C. This is within one-tenth of a degree from the average determined for *S. occidentalis* (Tanner and Hopkin, 1972) and only .2 C (32.6) from the mean temperature for a large series of *S. graciosus* from central Utah (Burkholder and Tanner, 1973). We suspect that higher maximum temperatures are reached but question that this species is very tolerant of the high temperatures of other species inhabiting the more open desert area. *Sceloporus magister* seems to confine its activities to areas where shelter and shade are available. Their tree climbing may also contribute to some temperature control by permitting individuals to get well above the intense heat of the desert floor where breezes provide for air circulation.

A male and female, particularly in the spring, often occupy the same basking site. As the season progresses there are fewer pairs seen. Usually by June the courtship is over and females occur singly. Copulation was not observed.

Reproduction

The reproductive cycles in *S. magister* are surprisingly similar to those recorded for *S. occidentalis* (Tanner and Hopkin, 1972) and for *S. graciosus* (Burkholder and Tanner, 1973). Although the general reproductive patterns are similar, there are some variations which will serve to distinguish *magister* from other *Sceloporus* seen by us.

Male Cycle: Although our gonadal series for some months is not large, a plotting of the data does provide a curve which seemingly depicts the cycle (Fig. 2). As in other species in the genus, the cycle moves slowly except for a brief period in June. At this time there is a sudden change resulting in a considerable decrease in gonadal weight and a rapid increase in size and weight of the fat bodies (Table 1). A fat body of five grams was recovered and is unusually large; however, we have other records for weights between two and three grams. In *magister* these large fat bodies are lobate as the liver but are readily distinguished by the grey greenish color.

Courting was observed in May, and pairs were regularly seen occupying the same basking site. The gonadal cycle suggests that mating occurs during May or early June. By mid-June the seminiferous tubes are undergoing a rapid regression, reaching a low point in late July or August (stage 8, after Mayhew, 1971), after which lizards are seen singly and courtship has ceased. The cycle is renewed (stages 1 and 2) in late August and September. We have not seen gonadal examples for late September or October. Examples seen in early April are in stages 4 and 5 suggesting that some development does occur between mid-September and the time of emergence in March. Stages 6 and 7 occur in May and June.

Males are not sexually mature until after the second hibernation. Although growth is rapid and continuous during that first full season, the gonadal cycle does not begin until the late summer and fall before the second hibernation.

Female cycle: Our earliest gonadal samples are for 8 April 1972. On this date the size of testes was much larger than ovaries in comparably sized lizards. The males were more obvious in the habitat and usually were in a dominant position at the basking sites. Indi-

Table 1. Gonadal and fat body cycles in male *S. magister* from the Nevada Test Site.

Cycle	April	May	June		July	August	Sept.
			early	late			
Gonadal	0.45(4)	0.52	0.51(3)	0.20(4)	0.08(4)	0.035(8)	0.12(3)
Fat Body	0.71		0.12	1.20	1.62	1.36	0.91

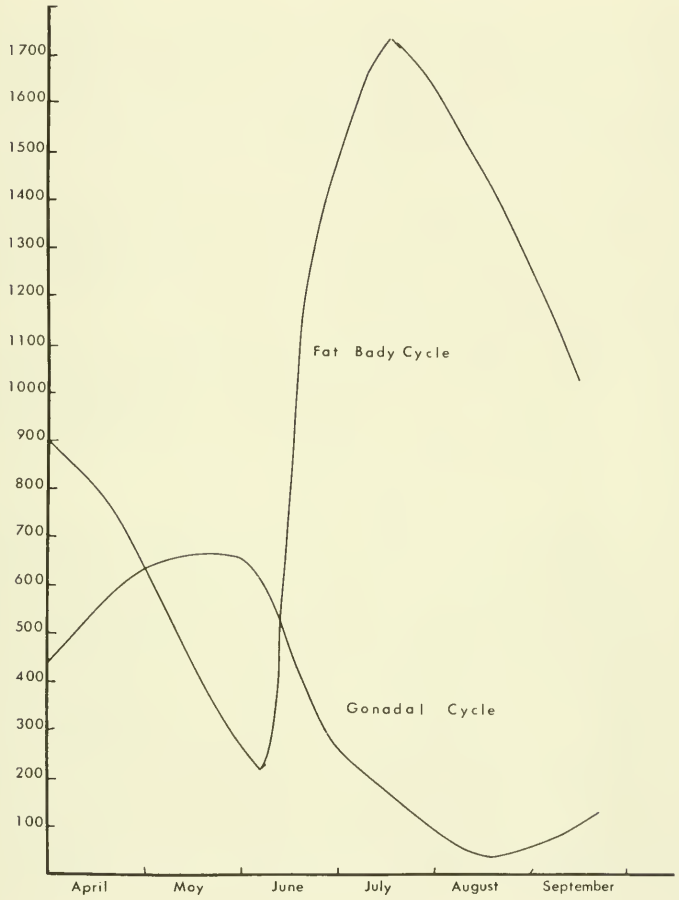

Fig. 2. The reproductive cycle as determined by the weight of testes and fat bodies, plotted in milligrams.

cations are that *magister* female behavior is similar to other northern *Sceloporus* species (*occidentalis* and *graciosus*) in that they emerge after the males have established their territories and are less obvious in the habitat until after mating.

Gravid females were observed in the field during late May and June. In 1966 and 1967 they were seen from 28 May until 16 June. In 1969, they were observed from 10 June to 28 June. Autopsied lizards that year showed oviducal eggs in mid-June. We note one exception in which there were 6 yolking ova, 7 mm in diameter, large fat bodies (1.06), and no corpora lutea for 28 June 1969. She was 97 mm SVL indicating adult size. We have noted an occasional female individual in other species to be slower than most others in a population.

Records for the Mercury Valley plot indicate that adult *S. magister* are in the plot during late May and June; we have only one record for July. Adults entering the plot were two females to each male and with few exceptions they were gravid. We saw one juvenile and five hatchlings during five years. About 300 m west (up slope) from the plot are some ledges and rocky habitat. We believe that the plot and adjacent areas were used as an area for egg laying by migrating females. We have one record in which No. 14 was marked on 11 June 1968, noted to be gravid, and weighed 34.28 g. On 28 June she was not gravid and weighed only 28.54 g. Most individuals were seen only once. Five were seen twice and with one exception (above) were caught within one week.

The study plot data do not satisfy completely our belief that the females of *magister* leave their home territory for depositing eggs as was reported for *S. olivaceus* by Blair (1960). While night driving, we saw a few female *magister* along roads on the test site. Invariably these were gravid females, perhaps attracted to the warm roads as they moved to an area for egg laying.

Four clutches of 4, 7, 7, and 10 eggs were laid in the laboratory on 25 June, 1972 and 20 and 26 June and 20 July, 1973. The clutch of 4 eggs averaged 0.86 (.75-.97)g and were 16.5 x 9 to 17.0 x 10 mm in size. Some captive females are reluctant to lay in confined areas. We suspect that the clutches listed above were held in the oviducts longer than is normal and thus the later dates. Two clutches of oviducal eggs were taken from autopsied lizards on 18 June, 1969. There were five and seven eggs per clutch, averaging 21 x 11 and 18 x 10 mm in size. On the basis of the size and weight of the one clutch, we estimate that the female in Mercury Valley (No. 14) laid six eggs. Available data suggest that the clutch size for *magister* in southern Nevada is in the range of 4-10 (avg. 7) eggs per clutch. This is noticeably less than in such species as *occidentalis* (Tanner and Hopkin, 1972) with 12, *olivaceus* (Blair, 1960) with 10, *clarki* (Kauffeld, 1943) with a record of 24, and *orcutti* (Mayhew, 1963) with 10-12.

Taylor (1936) reports a female from Sonora containing 18 well-developed eggs and Stebbins (1954) lists four clutches from lizards taken in southern California and central Baja California. These range from 7-18 eggs. The size of the females was not recorded and we cannot correlate numbers of eggs to the size (and perhaps the age) of the females. We do note in the size of eggs a relationship to numbers. Data on egg size are available from seven clutches (Stebbins, 1954, 4; our data, 3). The larger eggs were measured in the smaller and medium sized clutches and the smallest in the clutch of 18 eggs.

Apparently only one clutch is laid per year. Yolking and oviducal eggs are found in autopsied lizards from late May through June. None have been found in July. Field data also indicate that gravid females occur in the population from late May to late June but with none in July. In all years studied, by far the greater

number of gravid females was seen during the first two weeks of June.

Records from the literature also place egg laying during late May and June. Apparently this is the case for those populations occurring much farther south than southern Nevada, where the seasons are longer. Although our data and that from the literature are limited, we can see no indications that *S. magister* lays more than one clutch per year.

Soon after ovulation the fat bodies begin to increase in size. They are smallest in late May and until the eggs are laid in June (usually by 20 June). There is not always a complete loss of the fat body. The least we have recorded is 0.06 g on 18 June 1969. By July six females averaged 0.74 g and in August 1.06 g. In none of the females is the fat body as large as those recorded for males during July and August. The fat body cycle is similar to that observed in males (Fig. 2) but with an apparent lag of approximately two weeks after the eggs are ovulated.

Growth and Longevity

Growth

Hatchlings: This age group has been observed from 1966 through 1969. The earliest record for a hatchling is 27 July 1966. In 1969 the first was seen on 28 July. The smallest SVL recorded is 32 mm for one measured at the Mercury Valley plot on 22 August 1966. Two measured 34 mm at Cane Springs on 27 July 1966. The largest hatchling measured 41 mm on 7 August 1966 (Table 2). Although our data are not extensive and are incomplete for the fall months, they do indicate an extended hatching period of approximately one month from late July to late August.

Size of recent hatchlings seems to range in SVL from about 30-35 mm. From this size they grow rapidly, and some approach 50 mm by the time of hibernation. Growth for individuals was not determined; however, if we assume that those measuring 32-34 mm SVL are recent hatchlings (with weights of 1.00-1.50 g) then most hatchlings at least double their weight by the time of hibernation. Lizards having an SVL of 38-41 mm in August weighed 1.75-2.12 g.

Juveniles: More juveniles were captured and recaptured than hatchlings. This was particularly the case for the Knoll, where few hatchlings were seen. Hatchlings were flighty and readily sought cover when approached. Juveniles were bold and seemed to reappear soon after their initial hiding. Growth is rapid after emergence from the first hibernation. In April and May for most years measure-

Table 2. Range and average SVL for twenty hatchlings from the Cane Springs and Mercury Valley study plots.

Year	No.	Males	No.	Females
1966C	5	37.2(34-41)	3	36.3(34-37)
1968C	2	36.5(36-37)	5	36.2(34-38)
1966M	3	37.2(35-40)	2	34.0(32-36)

TABLE 3. Range and average SVL for thirty-seven juveniles. (K = Knoll, C = Cane Springs, F = Frenchman Flat)

Year	No.	Males	No.	Females
1966K	5	65.4(57-70)	2	62.5(62-63)
1967K	3	63.7(60-66)	3	53.7(50-57)
1968K			3	62.3(59-68)
1969K	2	73.0(71-78)	3	75.0(71-77)
1966C	2	67.5(65-70)	5	57.6(53-60)
1967C			2	61.0(59-63)
1970F	4	58.2(52-66)	3	60.0(55-65)
Total/Avg.	16	64.5(52-78)	21	61.2(53-77)

ments for SVL range between 50 and 60 mm, with a few in the low sixties. In Table 3 juvenile SVL measurements include those for April through July. August measurements are usually in the seventies and some individuals are approaching the size of adults and exhibit an adult color pattern.

Table 4 provides growth data for ten individuals. In most cases growth approximated 0.3 mm per day or a growth during May, June, and July of 25-30 mm. Such a growth rate is not attained by all individuals. We also note a slowing of the rate in July, perhaps because of a reduced food supply resulting from the hot and dry conditions which usually prevail. Late springs may retard the rate early in the season whereas an early spring provides for a rapid as well as a longer growth period.

TABLE 4. Measurements and growth rates for selected juveniles after the first hibernation. (C = Cane Springs, K = Knoll)

Toe Number	Date	Sex	SVL	Days Growth	Total Growth	Growth per day
7C	12 June 66	F	53			
	17 July 66		65	35	12mm	0.343
9C	16 June 66	F	60			
	25 July 66		75	39	15mm	0.384
11C	20 June 66	F	60			
	15 July 66		72	25	12mm	0.480
1-6C	16 June 67	F	63			
	7 Aug. 67		82	52	19mm	0.365
2-8C	17 June 68	F	59			
	9 July 68		67	22	8mm	0.364
2-9C	17 June 68	F	68			
	28 June 68		70	11	2mm	0.182
2-13C	9 July 68	F	69			
	2 Aug. 68		74	24	5mm	0.208
5K	31 May 66	M	57			
	15 July 66		72	45	15mm	0.333
4K	31 May 66	M	68			
	15 July 66		83	45	15mm	0.333
8K	8 June 66	F	63			
	29 June 66		65	21	2mm	0.095
	Total/Avg.			319	105mm	0.333

TABLE 5. Measurements for adults from four study plots at Nevada Test Site for the years 1965 through 1971.

Plot	No.	Males	No.	Females
Cane Springs	16	98.6(84-114)	20	93.2(88-102)
Frenchman Flat	22	101.6(87-112)	20	97.6(91-107)
The Knoll	11	97.4(83-115)	7	92.0(81-102)
Mercury Valley	4	96.0(90-100)	10	95.8(88-103)
Total/Avg.	53	99.40	57	95.04

Juveniles reach adult size by the time they hibernate in October. In September the gonadal cycle is paralleling that of adults and, except for a smaller size, these juveniles are functionally adults.

Adults: There is a slight sexual dimorphism in size with males averaging approximately 5 mm larger in SV lengths (Table 5). The smallest sexually mature female was 81 mm and the smallest adult male recorded was 83 mm SVL. The largest individuals in the population are males (Table 5). Data indicate that few females yolk eggs before they are approximately 90 mm SVL.

Adults continue to grow for at least three years. Young adults emerging from the second hibernation usually have a sustained growth for the first three months (April through June). This is not as great a growth in length as in hatchlings and juveniles; however, it does result in a noticeable increase in weight. By this time they have reached full adult size (90-100 mm) and have completed the first reproductive cycle. Examples of growth after the second hibernation are listed in Table 6. Records for individuals more than 30 months old show them to be 90 mm or more in SVL. A male individual from Cane Springs (18) marked on 9 July 1966 was 87 mm SVL, and estimated to be about 23 months old since no other juvenile seen by us reached such a size before late August. On 4 June 1968 he was 110 mm and on 7 May 1970, 114 mm. Although some individuals grow more rapidly than others, our data indicate that individuals measuring 100 mm or more in SVL are the older members of the population perhaps 4 or more years of age.

TABLE 6. Measurements and growth rates for selected individuals as juveniles and as adults after the second hibernation. (K = Knoll)

Toe Number	Date	Sex	SVL	Total Growth	Age (approximation)
3K	29 May 66	F	62		10 mo
	1 June 67		81	19mm	22 mo
5K	31 May 66	M	57		10 mo
	2 June 67		82	25mm	22 mo
8K	29 June 66	F	65		11 mo
	10 July 67		87	22mm	23 mo
19K	13 July 67	M	66		11 mo
	4 June 68		88	22mm	22 mo
1-5K	19 June 68	F	60		11 mo
	28 June 69		86	26mm	23 mo

Longevity

We have one record for a male known to be in his sixth year. Two males were marked at Cane Springs on 9 July 1966. Number 17 was a large adult, 110 mm SVL weighing 54 g. We estimate him to be at least 4 years old when marked. He was last seen on 15 June 1968, the same length but only 48 g. Number 18 was smaller, measuring 87 mm SVL and weighing 24 g. He was in his first year as an adult. He was last seen on 7 May 1970, appeared to be healthy, and weighed 59.13 g. Several records are for four years and two for at least five years.

Records for marked individuals and for those compared when autopsied indicate that the adult population consists mostly of lizards 3-5 years old but with a few older ones. The two oldest are both males; however, we do not consider this to imply that males live longer than females. The oldest females were 4 years. Our data are too limited to establish longevity differences between the sexes.

Food and Feeding Habits

This species is primarily an insectivorous feeder. Fig. 3 lists the types of food eaten as a percentage of individual items consumed. Only stomach contents were analyzed. Knowlton and Thomas (1934) and Knowlton and Nye (1946) reported on the contents of 49 and 12 stomachs from southern Utah. In both studies, ants were dominant food items. The desert scaly lizard, as with other sceloporines we have examined, is an opportunistic feeder. One adult male contained 1129 small ants. Four adults had eaten Isoptera and in each case large numbers (78-330) were consumed. The usual variety of arthropods are included in the diet throughout the year with an apparent increase in ants during July. This we do not understand unless it is attributable to the decline of vegetation (annuals and spring perennials) and the decline of insects as a result of the heat and drought; these conditions have apparently little effect

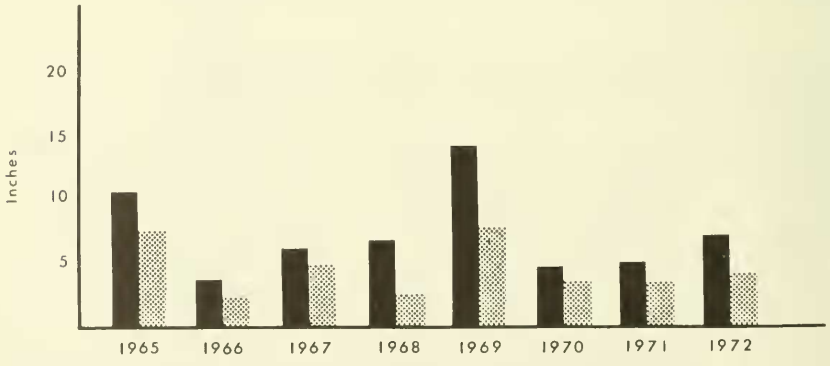

Fig. 3. Precipitation for an eight-year period 1965 to 1972. Dark columns for Cane Springs, dots for Well 5B (weatherstations in Frenchman Flat).

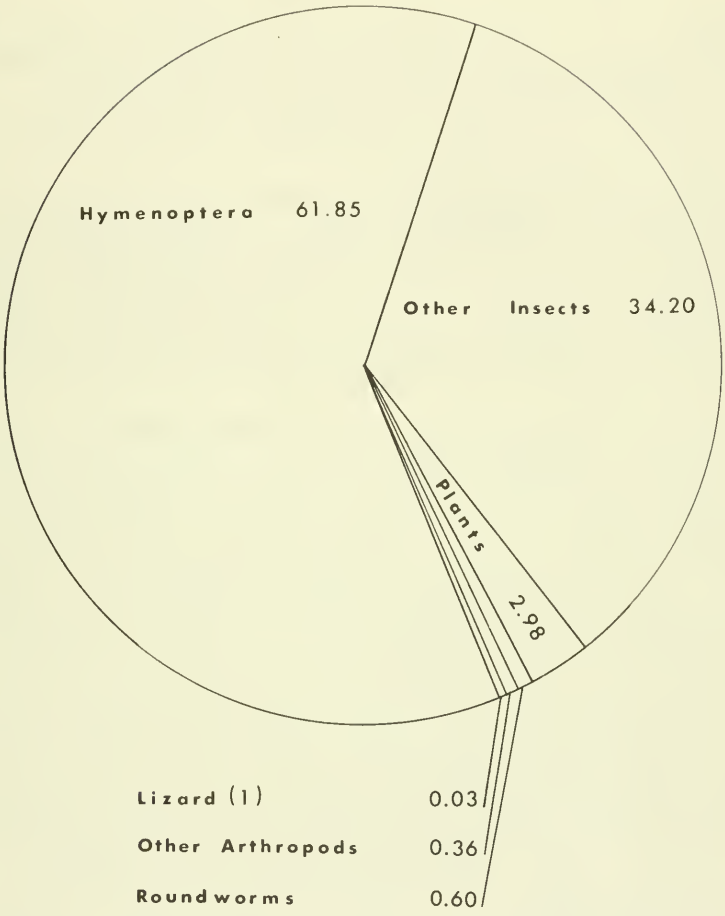

Fig. 4. Stomach contents plotted as a percentage of the items found in twenty-one stomachs in 1969.

in reducing the numbers of ants. Eighteen of 22 stomachs contained ants, which is higher than the ratio (29 of 49) found by Knowlton and Nye (1946). Knowlton and Thomas (1934) found one small *Cnemidophorus t. tigris* and some seeds and berries in stomach contents. We found one hatchling *S. magister;* we also found that several had consumed a number of plant parts, including 21 *Lycium* berries, a number of small rocks, and 18 round worms. A general list of the items recovered is in Fig. 4.

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